COMPUTING NUMBER SYSTEMS

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INTRODUCTION

My intentions for writing this article are twofold. Firstly, it is meant as an introduction to number bases (specifically those used in computing). Secondly, this text should be able to serve as a reference when trying to recall the methods of converting number bases and doing arithmetic with those bases specific to computing.

Numbers and their bases are of course the essence of math as well as computers. When I refer to a base I'm talking about the number of symbols used to represent a quantity before there is a shift in position. Let's take a look at the system you and I are most familiar with.

DECIMAL

Decimal has a base of ten meaning 10 values can be represented (numerals 0-9) before the magnitude is increased. If this doesn't immediately make sense maybe this example will clear things up:

```
157 = 1x10^2 + 5x10^1 + 7x10^0
      ------   ------   ------
    hundreds   tens     ones
```

The number 9 is the highest number that can be used before another symbol is necessary to show a higher magnitude. This problem is solved by using the same numerals placed at different positions. With the base 10 system each of these positions are incrementing powers of 10. The powers of 10 increase from right to left starting at 0 and going to *n*th power. If you wanted to represent fractional values then those would be represented by decreasing powers of 10 from left to right:

```
157.146 = 1x10^2 + 5x10^1 + 7x10^0 + 1x10^-1 + 4x10^-2 + 6x10^-3
```

BINARY

Although the decimal system is a convenient way for people to represent numbers it is inconvenient for computers. To understand why this is the case you must first be familiar with the terms analog and digital. When you are describing an analog system (ex: the temperature as shown by a thermometer) it can have a continuous set of values. In such a system determining the exactness of a value (is it 73.3 degrees Fahrenheit or 73.367?) can be difficult. Luckily most people don't care about anything past the decimal point and an analog system is fine when used to describe the temperature. Computers don't have this luxury and must have exact precision if they are expected to do anything meaningful with the data supplied. A way to get this exact precision is to use a digital system. This system only uses a finite set of values (ex: a stoplight - green, yellow, and red). Typically computers use the digital system more commonly known as binary. This is because there are only two possible states HIGH and LOW. I'll get into the whys behind binary in a different article. For now let's focus onthe system itself.

256	128	64	32	16	8	4	2	1
2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

This is the standard 8 bit binary table. The term bit is just shorthand for binary digit. The binary system is almost exactly like the decimal. Numerals are placed at different positions to show magnitude, powers increase from right to left starting at 0 and going to the *n*th power, fractions are decreasing powers starting at -1 and going from left to right, etc. There are only two differences. Binary uses a base of 2 and the only numerals available to fill that base are 1 and 0.